APPENDIX G-2

Oceanographic Data Collection and Evaluation: Phase 1 Status Report

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Long Island Sound Dredged Material Disposal EIS

Oceanographic Data Collection and Evaluation Phase I Status Report

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CONTENTS

LIST OF TABLES

LIST OF FIGURES

1.0 INTRODUCTION

The US Environmental Protection Agency (USEPA) and the United States Army Corps of Engineers, New England District (CENAE) are involved in the preparation of an Environmental Impact Statement (EIS) that will consider the potential designation of one or more dredged material disposal sites in Long Island Sound (LIS). To characterize the existing environment ENSR assessed existing hydrodynamic data in LIS to support evaluation of alternative open water disposal sites as part of the EIS. The hydrodynamics of Long Island Sound are an important component of the EIS process because the extent of dredged material transport in the open water environment is dependent on hydrodynamics. Specifically, ambient water currents can transport dredged material suspended in the water column during disposal events and can re-suspend and transport dredged material from the sea-floor via scouring following disposal events. Determination of the extent of dredged material transport in the open water environment is a critical component of the EIS process.

Federal regulations specify that a set of criteria be applied to support evaluation and potential designation of open water disposal sites (40 CFR Section 228.4(e), 228.5, and 228.6). These criteria include evaluation of physical, chemical, and biological characteristics, existing uses, and existing regulations at the site. In terms of hydrodynamic characteristics, the criteria specify that designated sites should afford minimal transport of dredged material away from the disposal site and that adjacent areas (e.g., fisheries and shorelines) should not be impacted. Evaluation of the potential for "dispersal, horizontal transport and vertical mixing characteristics of the area, including prevailing current direction and velocity, if any" (Section 228.6 specific criteria #7) is specifically required as part of the site assessment process. Assessment of near-bottom currents are of critical importance in evaluation of potential disposal sites due to the potential adverse effects of re-suspension and transport of dredged material from the sea-floor. The EIS hydrodynamic assessment will be designed and conducted to satisfy applicable regulatory requirements.

The EIS hydrodynamic assessment task will result in a Sound-wide hydrodynamic characterization and a set of detailed, site-specific hydrodynamic characterizations at selected locations. The Sound-wide hydrodynamic characterization will support evaluation of potentially suitable areas for open water disposal site designation throughout the Sound. Detailed, site-specific hydrodynamic characterizations will support evaluation of alternative sites in terms of hydrodynamic suitability. For example, water velocity measurements collected at alternative open water disposal sites will be compared to support selection of appropriate disposal sites for designation. Site-specific hydrodynamic characterizations will include evaluation of the extent of potential dredged material transport (e.g., near-field water column mixing and transport predictions) at identified alternative disposal sites. Sufficient data are required to support each of these hydrodynamic characterizations. Hydrodynamic data will be obtained through review and processing of existing data and through additional data collection activities, as needed.

Clearly, existing data and previous studies provide a basis and starting point for the EIS hydrodynamic evaluation task. The EIS hydrodynamic evaluation includes the following components:

- Acquisition and review of available physical oceanographic data;
- Identification and collection of additional physical oceanographic data; and
- Compilation and processing of available and additional data into a common database with distribution to interested parties.

The hydrodynamic characterization of Long Island Sound, required to support consideration of potential open water disposal sites, will be developed through a synthesis of existing and additional data, and previously performed hydrodynamic characterizations. Important existing hydrodynamic characterizations include Sound-wide physical oceanography studies, hydrodynamic data collection programs, hydrodynamic modeling applications, and dredged material disposal and erosion studies. Dredged material disposal and erosion studies have been performed at existing disposal sites and generally consist of empirical evaluations focused on assessment of the fate and transport of dredged material. These previous studies provide critical contextual information to support the EIS hydrodynamic assessment.

The EIS hydrodynamic characterization may require additional hydrodynamic modeling to expand the usefulness of data and to provide technically-defensible hydrodynamic characterizations in support of potential disposal site designation. Two types of modeling applications may be required. First, a Sound-wide hydrodynamic modeling application may be required to provide a technically-defensible basis for selection of alternative disposal site areas. Second, to support detailed, site-specific hydrodynamic characterizations, a modeling application using the ADDAMS modeling suite with recent revisions or a similar modeling package will likely be required. The ongoing EIS hydrodynamic evaluation has been designed to support hydrodynamic modeling applications that may be required as the process moves forward.

Performance of the tasks listed above will enhance understanding of hydrodynamics in Long Island Sound and support the EIS process. The contents of this status report are outlined below. Section 2 contains a brief summary of hydrodynamics and sediments in Long Island. Section 3 contains a summary of existing hydrodynamic data and Section 4 contains a preliminary set of recommendations for additional data collection. This summary provides an update of project status and reference information to support evaluation of potential additional data collection and evaluation tasks.

2.0 OVERVIEW OF HYDRODYNAMICS AND SEDIMENTS IN LONG ISLAND SOUND

A brief overview of Long Island Sound hydrodynamics, sediment composition, and sediment transport is provided below.

2.1 HYDRODYNAMICS

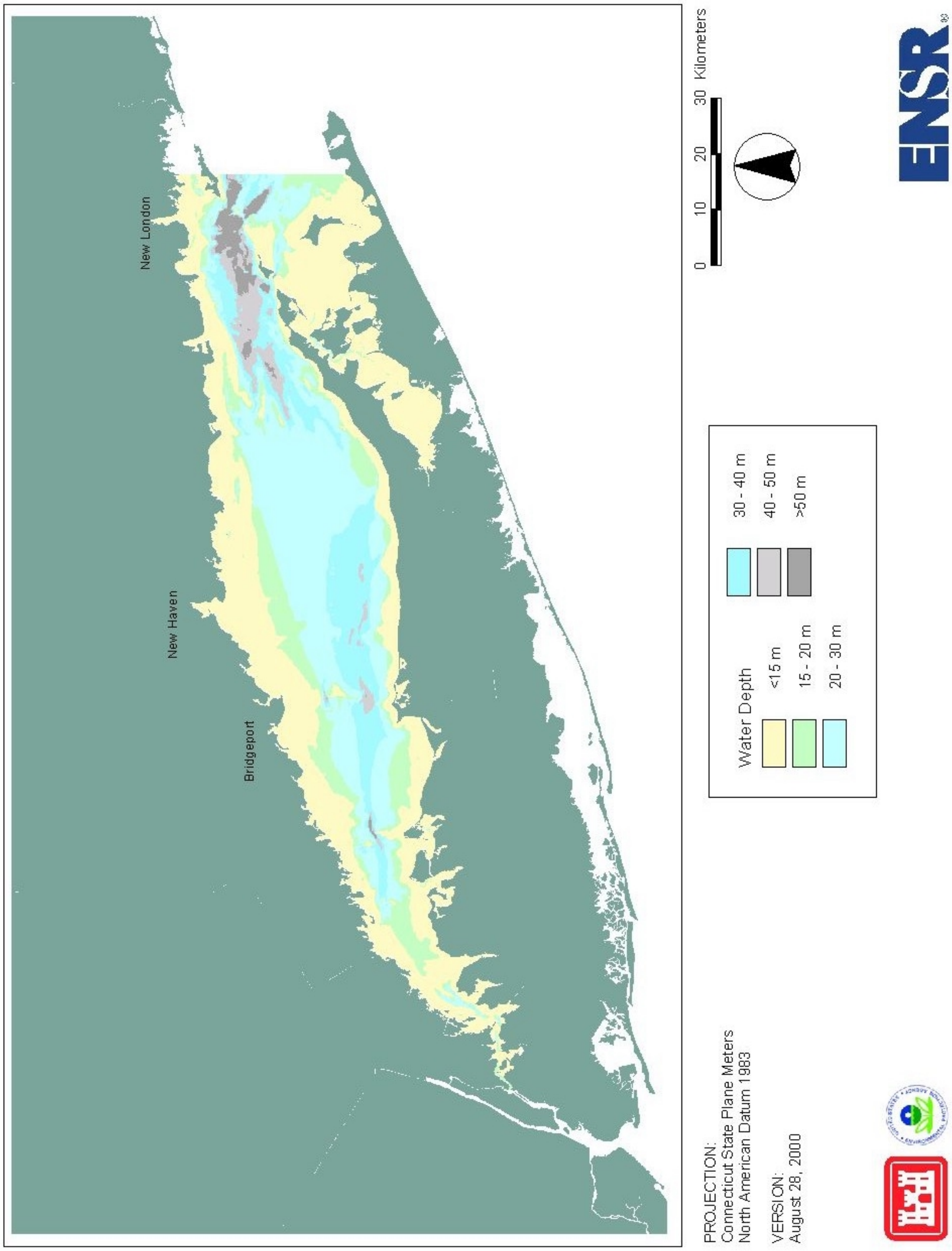
The hydrodynamics of Long Island Sound have been studied extensively through collection and analysis of field data and through mathematical modeling applications. Characterization of the currents and circulation patterns in the sound has provided an understanding of Sound-wide hydrodynamics and the observed sedimentary environments. A brief summary of general characteristics and previous hydrodynamic studies within the Sound is provided below.

Long Island Sound is approximately 90 miles long and 15 miles wide and oriented along a roughly east-west axis with open ocean exchange at eastern and western boundaries (Figure 1). The mean depth of the Sound is 20 meters and the maximum depth is 90 meters near its easterly boundary (Wolfe et al., 1991). Water movement in Long Island Sound is primarily driven by tidal forcings, with wind, storm events and freshwater inflows contributing to varying degrees. Storm events, producing wind-waves and establishing energetic flow regimes, combine with normal tidal forcings to create maximum water velocities and "worst-case" conditions in terms of potential dispersion of dredged material. Specifically, sustained storm events (e.g., 48 hours) featuring high winds along the axis of the Sound (i.e., roughly east-west) are expected to produce maximum bottom currents and potentially result in maximum sediment re-suspension in the Sound.

Water velocity magnitudes are observed to be greatest Eastern Long Island Sound and generally diminish with distance west. The amplitude of the M2 tide, the dominant tidal constituent, increases by a factor of 3 between the east and west end of the Sound, with similar decreases in water velocity indicating that the Sound is a resonant basin (Gordon, 1980). Tidal currents are generally oriented along the east-west axis of the Sound.

Although the Sound is not a typical estuary, with a river at the upstream end, well-developed estuarine circulation has been observed. In general, fresher, less dense water flows eastward along the surface, while saline water flows westward along the bottom of the Sound. There is a general counter-clockwise circulation in Long Island Sound, with currents along the north shore heading to the west and currents along the south shore heading east. There is also evidence for several localized gyres within the body of the Sound (Welsh, 1992)

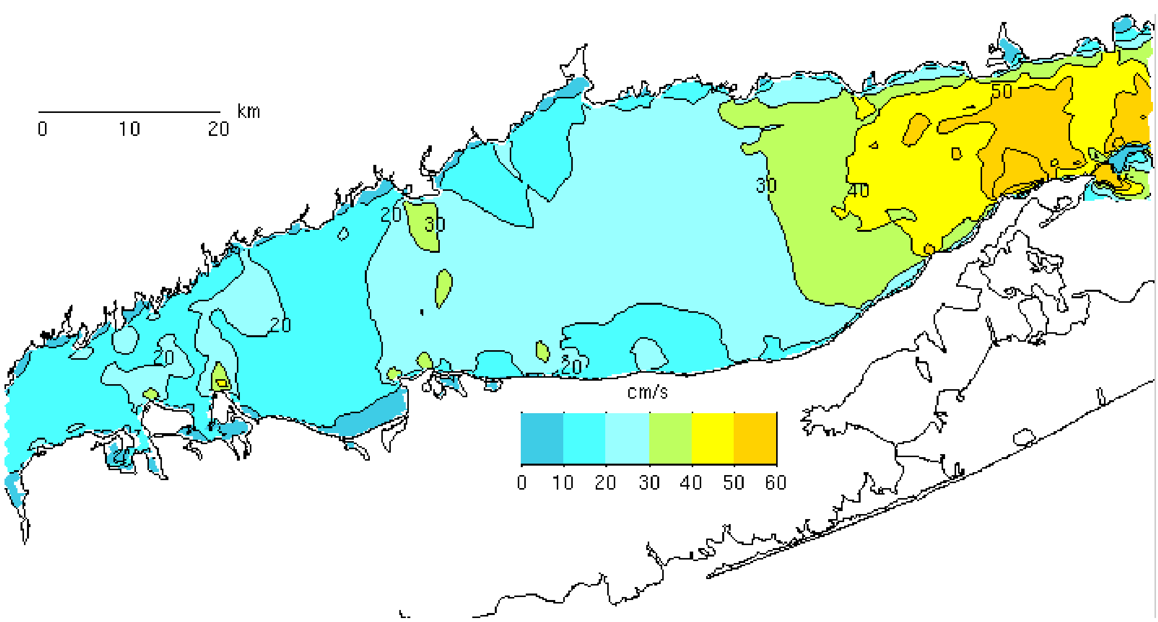
FIGURE 1   MAP OF LONG ISLAND SOUND WITH BATHYMETRY



Schmalz (1993) applied a three-dimensional hydrodynamic model to decompose the residual circulation into individual forcing components. He examined the relative effects of astronomical tide, density-driven currents, local wind driven currents and non-local shelf wind driven currents on the residual circulation patterns. Model simulations revealed the presence of counterclockwise gyres in the western and central basin, set up by the astronomical tide alone, and enhanced by the gravitational forcing due to density gradients. Near the surface of the water column, Schmalz found that forcing due to astronomical tide, density gradients and local wind were of the same order of magnitude, while the contribution of non-local shelf winds was an order of magnitude lower. Near the bottom of the water column, astronomical and density-driven forcings were slightly higher than local wind forcings, and non-local shelf winds had no effect on the predicted residual currents.

The U.S. Geological Survey set up a three-dimensional hydrodynamic model to predict bottom currents and to characterize the sedimentary environment of the Sound (Signell et al., 1997). The model included tidal and local wind forcings and assumed uniform density. The model predicted bottom currents 1 meter above the bottom throughout Long Island Sound (see Figure 2). The model predicted tidally-driven bottom currents of less than 20 cm/s in the western portion of the Sound, between 20-40 cm/s in the central Sound, 30-60 cm/s in the eastern Sound, and greater than 50 cm/s in the constriction at the eastern end of the Sound. Areas where the model predicted bottom currents greater than 30 cm/s corresponded to regions identified as erosional or non-depositional. In near-shore regions (water depth less than 20 m), wind-generated waves were found to contribute significantly to bottom orbital velocities and sediment transport.

FIGURE 2 PREDICTED BOTTOM CURRENTS AT 1 M ABOVE THE BOTTOM (FROM SIGNELL ET AL, 1997)



Vieira (2000) analyzed a series of velocity measurements to examine the long-term, residual circulation in the Sound. By filtering and averaging each data set, Vieira was able to describe residual flow patterns resulting from tidal and gravitational forcing, independent of time or specific events. Vieira observed denser, saline water entering the Sound from the east and flowing underneath outgoing, less saline water, indicative of classic estuarine circulation. In the Central Basin, he observed the incoming, saline water flowing through the deep, southern part of the sound, and the outgoing water flowing above it at lower speeds. In the Western Basin, outgoing flow is generally along the southern shore of the sound, and in the upper part of the water column, as the estuarine circulation is established. A counterclockwise gyre is discernable in the Western basin, consistent with the modeling results of Schmalz.

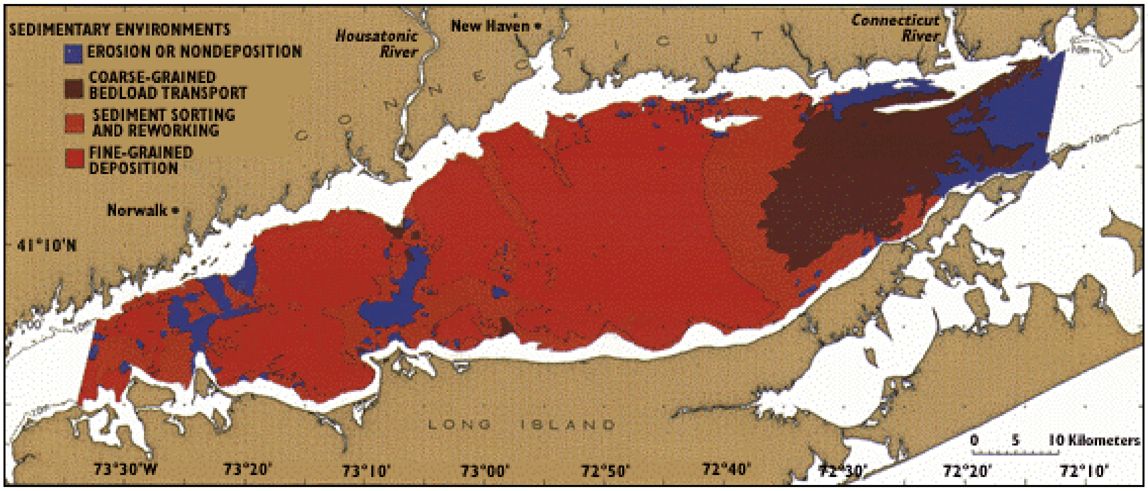
Kaputa and Olsen (2000) conducted a review of seven years of water quality data, primarily to understand the spatial and seasonal patterns of hypoxia in Long Island Sound. Time series measurements of temperature and salinity indicated a density stratification in the water column. The data revealed a strong temperature gradient, with warmer water above cooler bottom water. The temperature gradient was largest during June and early July, likely driven by warming air temperatures. Salinity gradients have also been observed, when saline water flows below fresher water, as previously described. These vertical density gradients lead to stratification in the water column, which contribute to the observed flow patterns in the Sound.

2.2 SEDIMENTARY ENVIRONMENT

The bottom sedimentary environment of Long Island Sound has been characterized by the U.S. Geological Survey, in cooperation with the Connecticut Department of Environmental Protection and the U.S. Environmental Protection Agency (Knebel, 1998). The sedimentary environment is indicative of the movement and deposition of sediments in the sound due to local and regional geologic and oceanographic conditions.

To characterize the sedimentary environment of Long Island Sound, the USGS conducted an extensive survey of the sea floor. Sidescan sonographs were collected and analyzed with the aid of sediment grab samples and video camera observations. Four long-term sedimentary environments were identified: erosion or non-deposition; coarse-grained bedload transport; sediment sorting and reworking; and fine-grained deposition (see Figure 3).

FIGURE 3 SEDIMENTARY ENVIRONMENTS ON LONG ISLAND SOUND (FROM KNEBEL, 1998)



At the eastern edge of the sound, extending approximately 5 to 8 km west, there is a large area of erosion or non-deposition, likely caused by combination of strong tidal currents and a net westward movement of sediments into the estuary (Knebel, 1998). West of this region is an area of coarse-grained bedload transport. This region extends approximately from the mouth of the Connecticut River westward 15 km, and is bordered on the western edge by a 5-km band of sediment sorting and reworking. The seafloor in this region is primarily sand, and transitions gradually to marine mud towards the central basin. The central and western basins of the sound are predominantly regions of fine-grained deposition. In localized areas, generally along north-south oriented shoals, there are regions of erosion or non-deposition and sediment sorting and reworking.

Turbidity measurements indicate that waves influence sediment transport around the margin of the Sound, up to depths of approximately 18 m (Bokuniewicz and Gordon, 1980). Within this margin, the bottom sediments are primarily sand, transitioning to mud with greater depths. In these deeper regions of the Sound, waves are expected to have little influence on sediments.

2.3 SEDIMENT TRANSPORT

The primary source of sediment entering the Long Island Sound is river inflow. Sediment loading from rivers varies greatly, with the majority being delivered during periods of storms and subsequent high discharge. Estimates of the load contributed by the Connecticut River (which contributes 71% of the total freshwater inflow) range from 0.8 x 10^8 kg/yr to 5 x 10^8 kg/yr (Bokuniewicz and Gordon, 1980). In general, sediment loading from rivers into the Sound is less than that of other estuaries, due to the erosion resistance of the glacial terrain that covers much of central New England (Gordon, 1980). Other sources of sediment include shoreline erosion and exchange with the continental shelf, both of which have not been well quantified, but are considered to contribute less than river inflow. Estimates of sediment supply into the Sound and sedimentation within the Sound are nearly equal, suggesting that the trapping efficiency of the Sound is nearly 100% (Gordon, 1980).

Sand transport (particle size >70 µm) covers approximately 44% of the floor of the Sound (Bokuniewicz, 1980). As mentioned above, the eastern portion of the Sound floor is covered by sand, transitioning westward to mud. The eastern edge of this transition zone is a north-south sand ridge called Mattituck Sill. The Sill is covered with sand waves, and sand movement occurs primarily as bedload transport. A net westward flux of sand has been calculated in this region, attributed to the superposition of the estuarine current on the tidal currents (Bokuniewicz, 1980). As the sand moves westward, it is immobilized by incorporation into the mud deposits that cover the central and western regions of the Sound.

The silt and clay particles that enter the sound are rapidly processed by benthic animals, which produce aggregate pellets (100 – 500 µm). The lack of individual particles with the Sound indicate that the rate of pellet production by the benthic community is large compared to the rate of sediment supply (Bokuniewicz and Gordon, 1980). A 10 mm layer of these pellets blanket the mud-dominated portions of the sea floor throughout the Sound. This layer can be re-suspended into the water column due to tidal excitation and storm events. Only during the largest storm events is the entire layer re-suspended. At the bottom of this layer, the pellets are converted into cohesive sediments, and are no longer subject to re-suspension. This mud, or permanent sediment, is estimated to accumulate at an approximate rate of 1 mm/yr. The production of new pellets maintains the approximately constant thickness of the upper, mobile layer of particles.